DCGAN

(Deep convolutional GAN)

2019.06.22

Lee Jun Seong

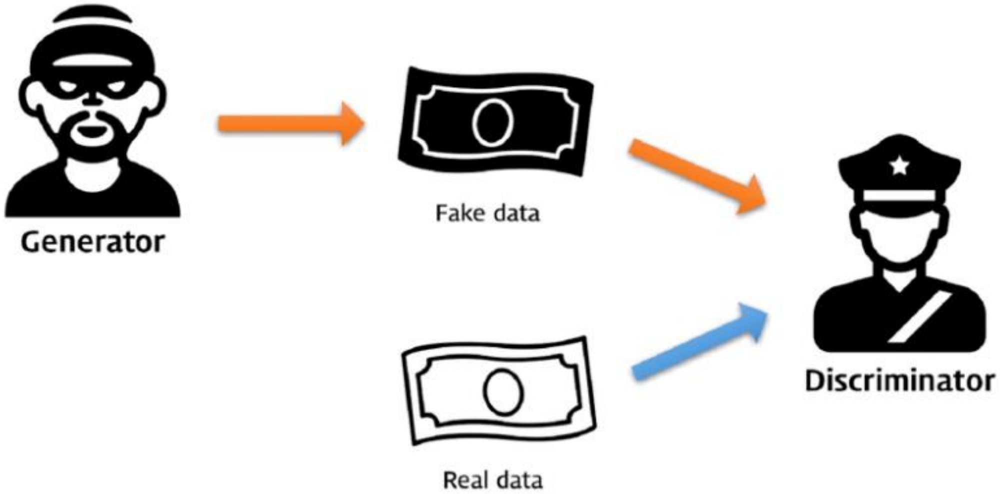
MI2RL

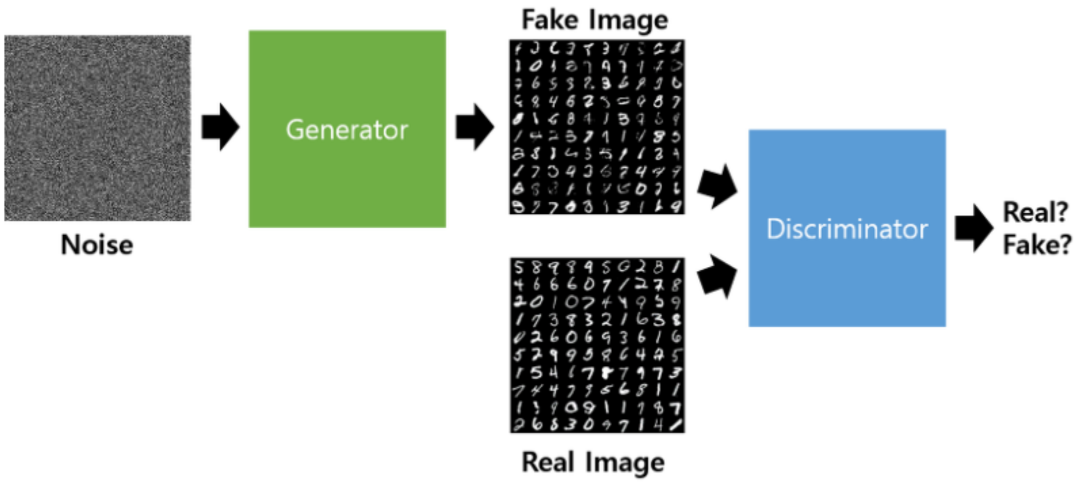
UNIVERSITY OF ULSAN COLLEGE MEDICINE

ASAN Medical Center

GAN

Review for GAN (generative adversarial network)





GAN

- **Problem**
  - **Stability**
  - **Quality**
  - **Black-box method (Visualization)**

UNSUPERVISED REPRESENTATION LEARNING WITH DEEP CONVOLUTIONAL GENERATIVE ADVERSARIAL NETWORKS

Alec Radford & Luke Metz
indico Research
Boston, MA
{alec,luke}@indico.io

Soumith Chintala
Facebook AI Research
New York, NY
soumith@fb.com

https://arxiv.org/pdf/1511.06434.pdf

DCGAN

- **DCGAN (Deep convolutional GAN)**
  - Generator & Discriminator networks: MLP → CNN

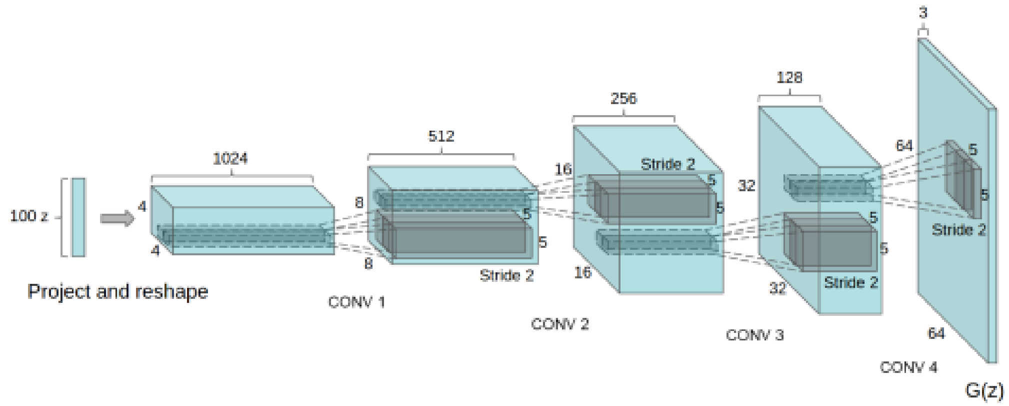


Figure 1: DCGAN generator used for LSUN scene modeling. A 100 dimensional uniform distribution Z is projected to a small spatial extent convolutional representation with many feature maps. A series of four fractionally-strided convolutions (in some recent papers, these are wrongly called deconvolutions) then convert this high level representation into a 64×64 pixel image. Notably, no fully connected or pooling layers are used.

- **Contribution**
  - **대부분의 상황에서 안정적으로 학습**되는 Convolutional GAN 구조 제안
  - **벡터 산술 연산이 가능한** Generator (semantic 수준에서의 sample generation)
  - DCGAN이 학습한 특정 **filter 들을 시각화하여 이미지의 특징을 학습했다는 것을 보여줌**.
  - 이렇게 학습된 Discriminator가 다른 비지도 학습 알고리즘들과 비교해 비등한 이미지 분류 성능을 보임

DCGAN

- **Architecture**
  - (Extensive research and testing) 엄청난 시도를 통해 얻어진 결과

Architecture guidelines for stable Deep Convolutional GANs

- Replace any pooling layers with strided convolutions (discriminator) and fractional-strided convolutions (generator).
- Use batchnorm in both the generator and the discriminator.
- Remove fully connected hidden layers for deeper architectures.
- Use ReLU activation in generator for all layers except for the output, which uses Tanh.
- Use LeakyReLU activation in the discriminator for all layers.

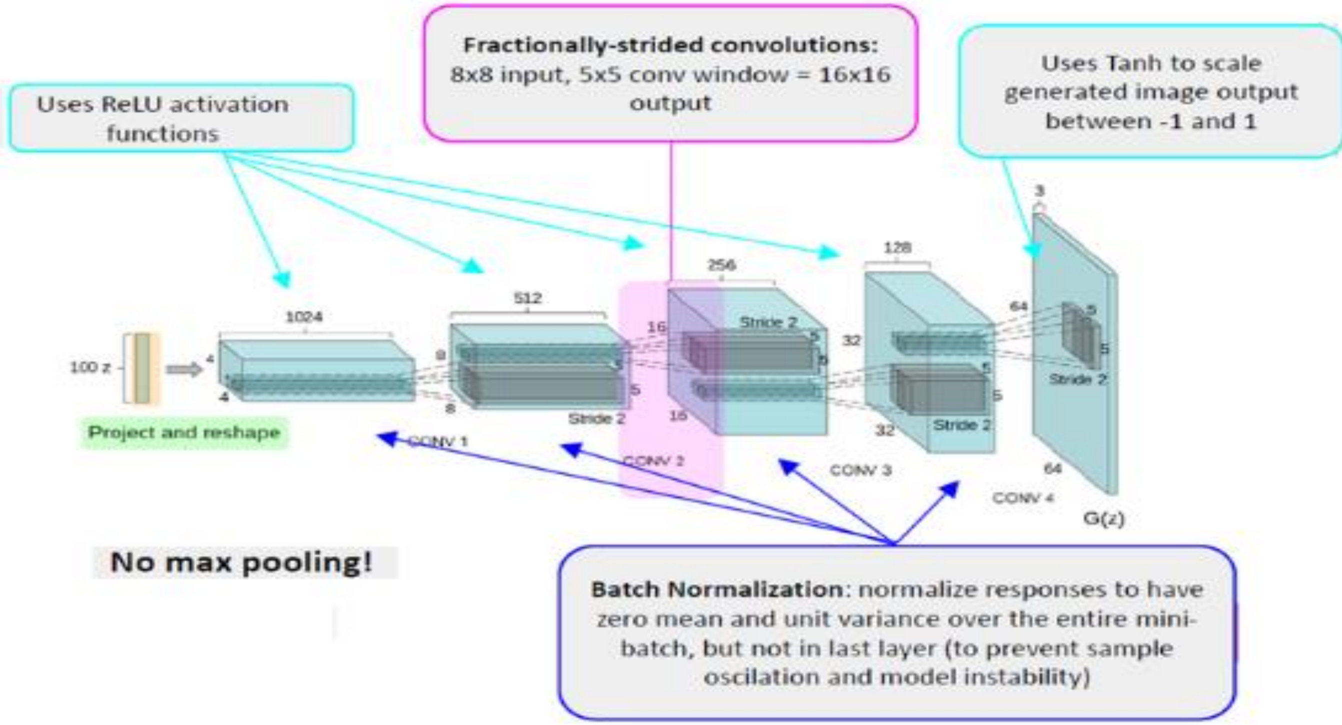
  - Deterministic spatial pooling → **Strided convolutions (discriminator) and fractional-strided convolutions (generator), allowing the network to learn its own spatial downsampling or upsampling.**

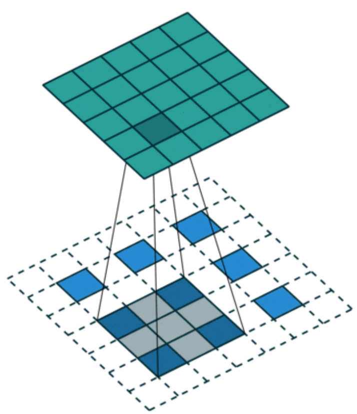
  - Batch normalization **(Except for generator output layer and discriminator input layer)**

  - Pre-processing → [-1, 1]
  - Mini-batch size of 128.
  - Adam optimizer (learning rate: 0.001 → 0.0002, Momentum = 0.9 → 0.5)

DCGAN

- **Architecture**
  - Generator

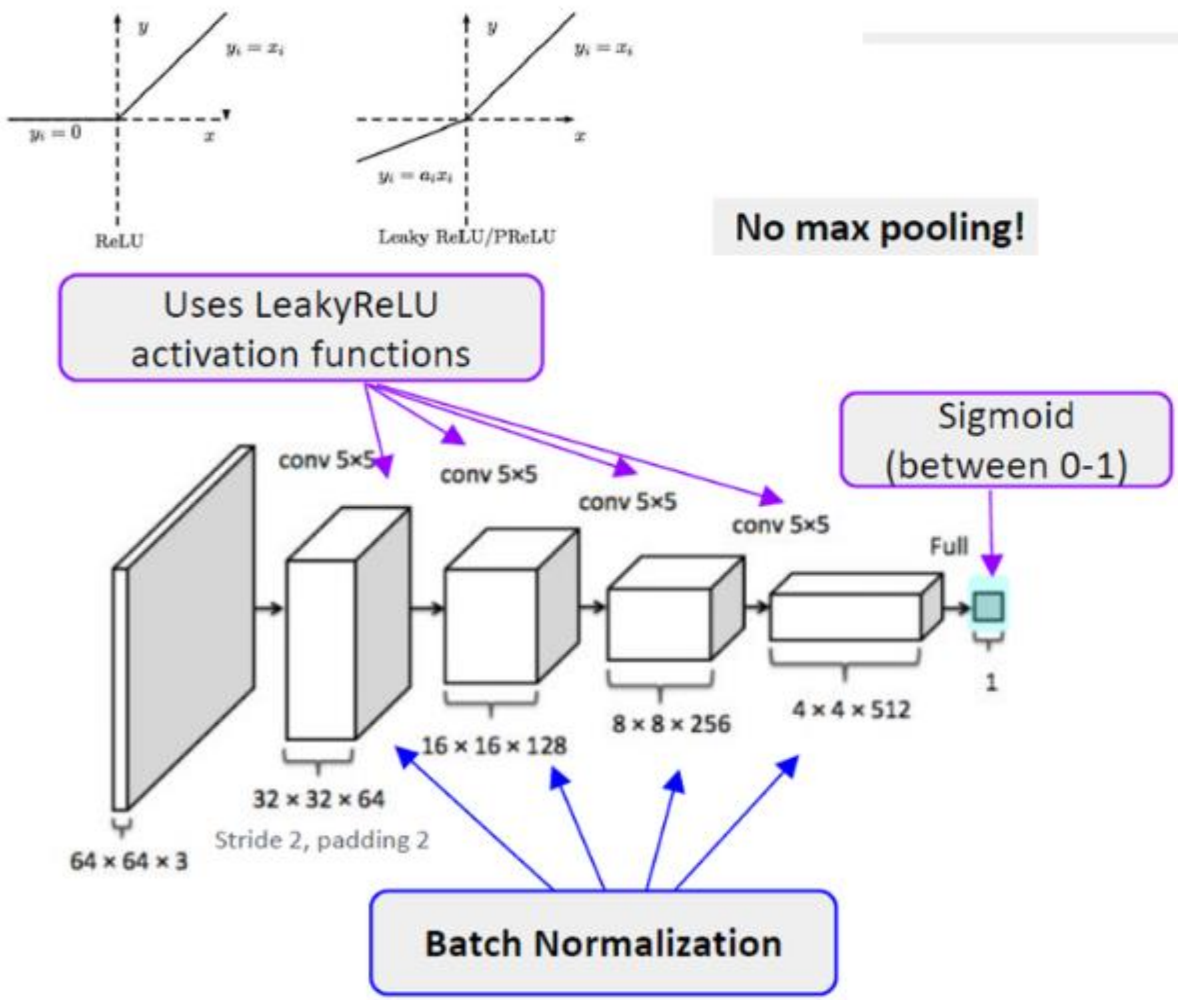




Fractional strided convolution

DCGAN

- **Architecture**
  - Discriminator



DCGAN

- **Result**
  - LSUN dataset (침실 데이터)
    GAN에 의해 생성된 영상이 Training data의 Overfitting/Memorization이 아님을 증명.
    (특징을 학습하는게 아니라 영상 자체를 외워버리는 것이 아니냐는 비판을 받았기 때문)
    *Deduplication

1 epoch 학습 후 결과 → Mini-batch로 1 Epoch 학습한 영상으로 네트워크가 Training data를 Overfitting/Memorization 할 수 없음에도 침실 비슷한 결과를 보여줌.

DCGAN

- **Result**
  - LSUN dataset (침실 데이터)

5 epoch 학습 후 결과 → 자세히 보면 그림의 몇몇 침대의 Base board에 noise texture가 반복적으로 나타나고 있는데 이런 점을 통해 5 epoch 동안도 여전히 Under fitting 상태임을 알 수 있다. → Overfitting 안됐다는 것을 강조하고 싶음.

DCGAN

- **Result**
  - Classifying CIFAR-10 using GAN as a feature extractor
    GAN이 얼마나 Unsupervised representation을 잘 학습했는지 평가하는 한 방법으로써, 학습된 GAN을 supervised datsets 에 대해 feature extractor로 사용해보는 것.

> To evaluate the quality of the representations learned by DCGANs for supervised tasks, we train on Imagenet-1k and then use the discriminator's convolutional features from all layers, maxpooling each layers representation to produce a 4 × 4 spatial grid. These features are then flattened and concatenated to form a 28672 dimensional vector and a regularized linear L2-SVM classifier is trained on top of them.

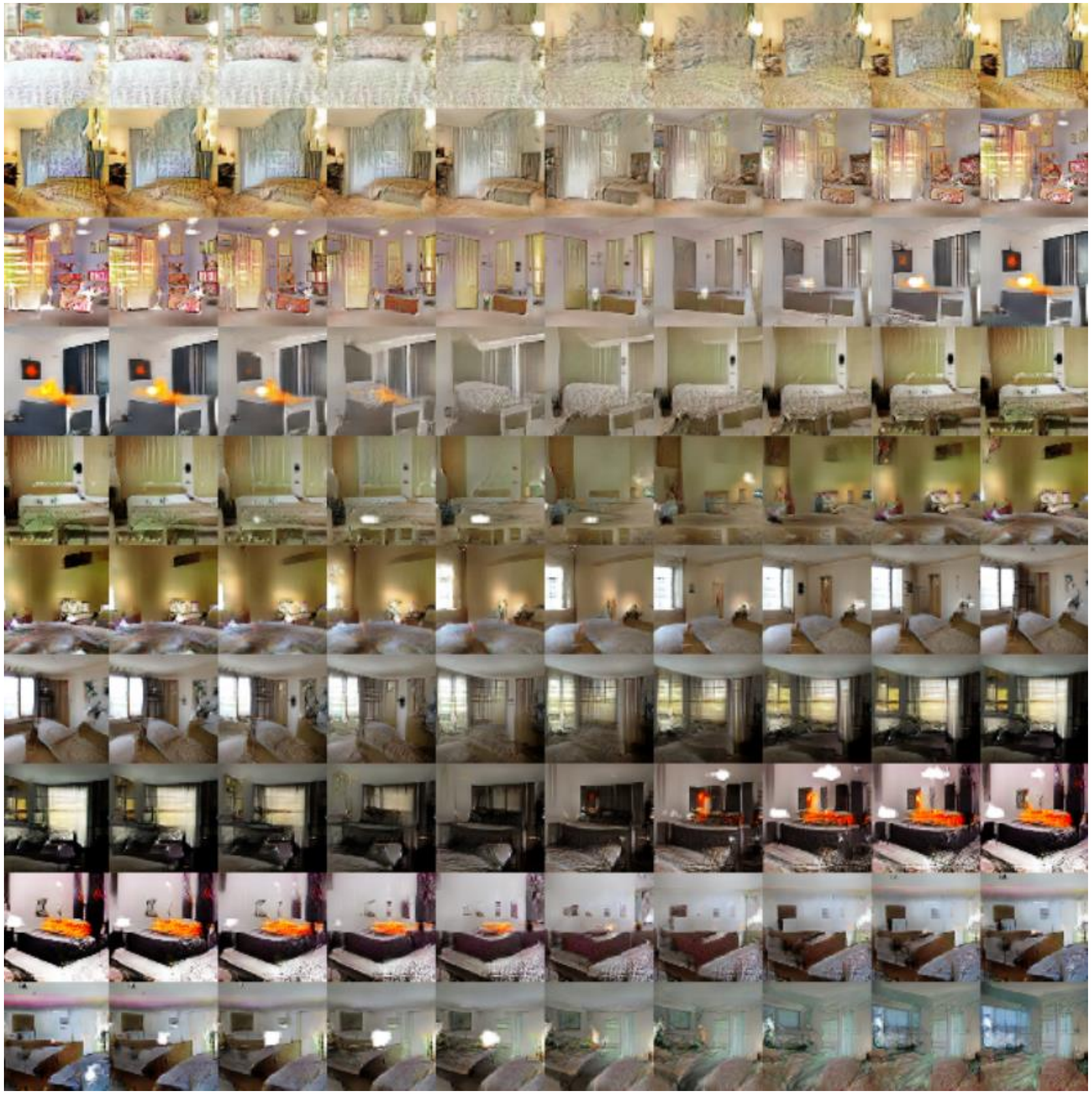
Imagenet-1k 데이터로 GAN을 학습 → CIFAR-10 dataset 에 대해 Discriminator로 Feature extraction 후 최종단에 SVM을 연결하여 분류.

Model	Accuracy	Accuracy (400 per class)	max # of features units
1 Layer K-means	80.6%	63.7% (±0.7%)	4800
3 Layer K-means Learned RF	82.0%	70.7% (±0.7%)	3200
View Invariant K-means	81.9%	72.6% (±0.7%)	6400
Exemplar CNN	84.3%	77.4% (±0.2%)	1024
DCGAN (ours) + L2-SVM	82.8%	73.8% (±0.4%)	512

기존의 Unsupervised representation learning algorithm 들과 비교해도 비등하다.
(단, DCGAN의 경우 CIFAR-10 data에 대해 학습되지 않기에 domain robustness를 강조)

DCGAN

- **Result**
  - Walking in the latent space



DCGAN

- **Result**
  - Visualizing the discriminator features

Random filters　　　　Trained filters

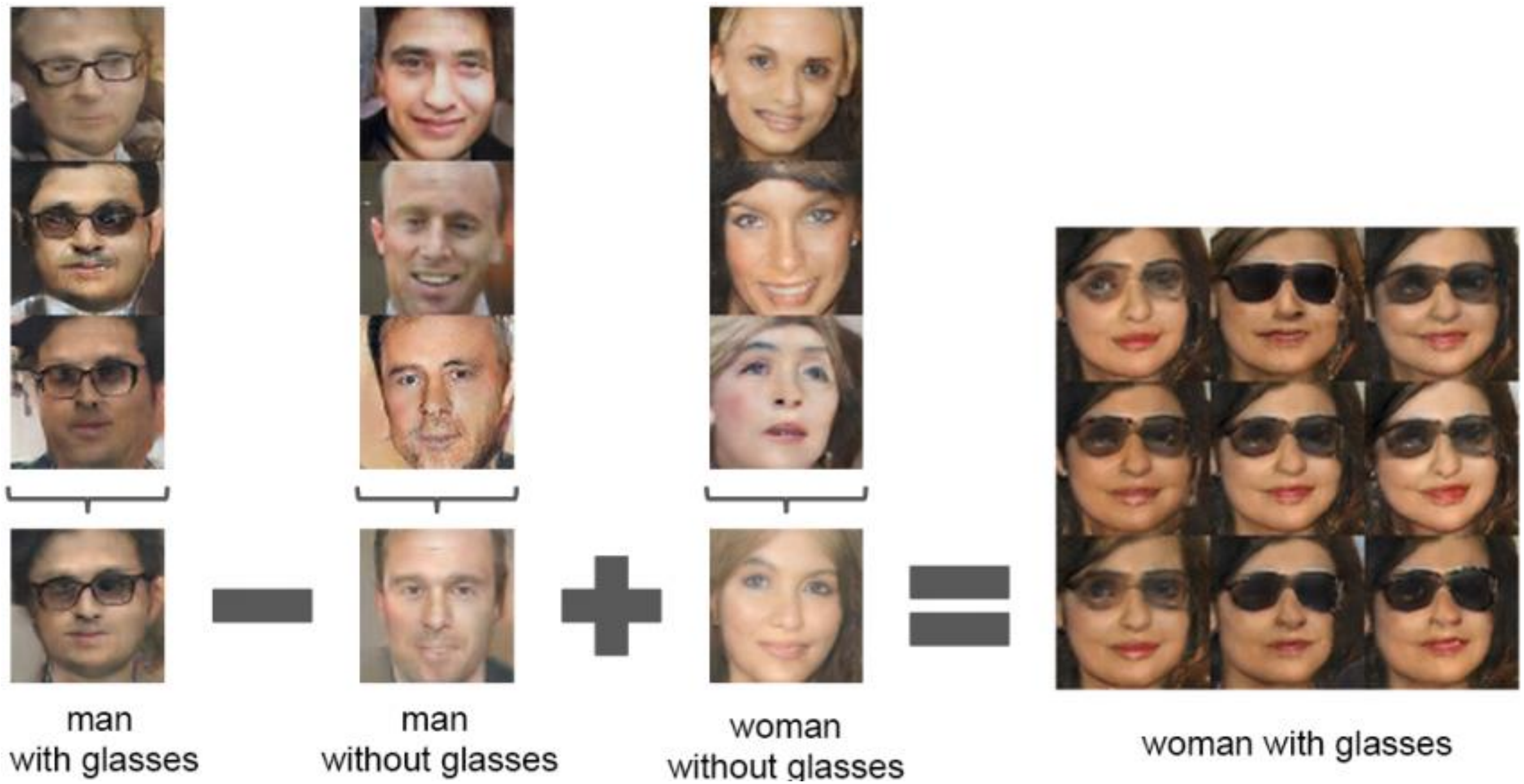
DCGAN

- **Result**
  - Forgetting to draw certain objects

"Window" representation 을 학습한 filter를 dropout하니 Window가 없는 영상을 생성.

DCGAN

- **Result**
  - Vector arithmetic on face samples



DCGAN

- **Result**